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A visibility-based implementation of the fast-folding algorithm for efficient wide-field periodicity searches

Andrew Zic(1), Ryan White(2), Vivek Gupta(1), Ziteng Wang(3), and Keith Bannister(1)
(1) ATNF, CSIRO, Space and Astronomy, PO Box 76, Epping, NSW 1710, Australia
(2) School of Mathematical and Physical Sciences and Astrophysics and Space Technologies Research Centre, Macquarie University, NSW 2109, Australia
(3) International Centre for Radio Astronomy Research, Curtin University, Kent Street, Bentley WA, 6102, Australia

Conventional periodicity searches in radio astronomy datasets predominantly use single-pixel time-series data. These data are collected by single-dish telescopes (possibly equipped with focal-plane array receivers, giving multi-beam capability), or from tied-array beams formed by an array telescope. However, these single-pixel time-series datasets have limited sensitivity to periodicities longer than about 10 s, owing to gain fluctuations arising from the system electronics and a variable sky response. Moreover, tied-array beam surveys are computationally expensive, often requiring hundreds of beams to be formed to cover the field of view. In the rapidly approaching era of large-scale array telescopes, such as the SKA-Mid, SKA-Low, and DSA-2000, tied-array pulsar searches will require a formidable expenditure of computational resources.

In this work we present a novel implementation of the fast-folding algorithm to interferometric visibility datasets. The implementation works on gridded visibilities, where the FFA is applied to the visibility time-series of each (u,v) cell sampled by the interferometric observation. Due to the inherently sparse (u,v) sampling, FFAs are performed on only a fraction of the total number of pixels needed to construct the corresponding sky images for each time sample. The additive nature of the FFA applied along fixed (u,v) coordinates preserves the visibility amplitude and phase information required to reconstruct an image for a given period trial and phase bin, thereby enabling detection of any periodic source within the telescope field of view.

This implementation delivers two key benefits of interest to current and future-generation survey instruments: 1) the ability to calibrate the instrumental gains and to model and subtract the sky continuum emission from the visibilities; 2) the $N \log N$ efficiency of FFT-based imaging which, greatly improves efficiency for carrying out periodicity searches over the array field of view. The outcomes of this implementation include greatly improved sensitivity to long-period sources, and significant reduction in computational cost for wide-field periodicity searches compared with beamforming-based approaches.

In this talk, I will describe the algorithm in detail and demonstrate its efficacy. I will discuss the scientific use-cases for this alogrithm, immediate plans for its application to current and upcoming widefield radio surveys, and its applicability to next-generation sky surveys.